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STRATEGIC ENVIRONMENTAL ASSESSMENT SYSTEM: (SEAS). A RESEARCH PROJECT

Stanley M. Greenfield

Washington Environmental Research Center

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STRATEGIC ENVIRONMENTAL ASSESSMENT SYSTEM: (SEAS)

A RESEARCH PROJECT

AN ADDRESS BY
Dr. Stanley M. Greenfield
Assistant Administrator
for Research and Monitoring

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MAY 14-15, 1973

U.S. ENVIRONMENTAL PROTECTION AGENCY • WASHINGTON, D.C. 20460

FOREWORD

The following material has been compiled to provide convenient and concise updated information on SEAS. The material was presented at the National Conference on Managing the Environment conducted by EPA in Washington, D.C. May 14-15, 1973. Included is an address on SEAS by Dr. Stanley Greenfield, Assistant Administrator for Research and Monitoring and briefing charts utilized in a Technical Workshop on SEAS at the Conference.

The Strategic Environmental Assessment System (SEAS): A Research Project

An Address
by
Dr. Stanley M. Greenfield
Assistant Administrator for
Research and Monitoring

I am pleased to discuss with you this morning a research project underway in my office to develop a Strategic Environmental Assessment System, known as SEAS. This project is particularly appropriate in the context of this conference and especially within the scope of this session on Environmental Technology. As you will see, the SEAS project is based upon the fundamental premise that modern computer technology, when combined with expert opinion, can if applied properly be of significant value in assisting public decision makers at all levels of government in understanding the complex interrelationships of the environment and the less apparent consequences of our current and contemplated policies and actions.

The EPA is charged to carry out a program that will result in the protection of the environment of the nation by abating or avoiding pollution. Currently, this program is primarily regulatory in form. In response to this charge, the program of my office is structured so as to emphasize the accomplishment of the following six major goals:

1) The development of appropriate science and technology for setting and enforcing pollution control standards;

2) The full understanding of the environmental impact of that which we are mandated to control;

3) The knowledge of what it "costs" to meet environmental quality standards;

4) Knowledge of the "costs" of not meeting environmental standards (i.e., the benefits to be derived from meeting them);

5) Monitoring, to meet environmental goals; and

6) Establishing the means to forecast the long-range effects

of societal actions so as to avoid deleterious environmental impacts.

The SEAS project is primarily focused on this last goal and is primarily concerned with developing an improved capability to strategically assess the comprehensive and long-range environmental effects of various policies upon society.

It is clearly recognized that the acquisition of such a capability involves a number of very difficult obstacles. In this connection it is instructive to consider a number of the more apparent problems that beset any such endeavor.

First, there is the critical issue of uncertainty. No one factor exemplifies this issue more than the attempt to predict future technological trends. Technological trends are perhaps the most critical component of any forecast of the future, but also the most difficult to assess. The institutionalization of R&D efforts has, to some extent, alleviated the problem of anticipating new technologies, but the nature and timing of technological "breakthroughs" and, more importantly, the rate of implementation, remain subject to many unpredictable factors. One thing we have learned is that there is wide variation in the rate of adoption of new technologies.

A corollary issue with respect to technological forecasting is predicting impacts upon society. We know from experience that institutional and social factors and values are fundamental to environmental quality, yet our ability to predict such changes is equally difficult. For example, assessing the first-level impact of new technologies upon the economy is problematical in itself; but predicting the secondary effects of technology on human life styles, urban form, and behavioral patterns and values is extremely complex.

Secondly, we face the issue of the interrelationships of factors and the nature and degree of interaction. It is obviously not sufficient to state that environmental factors are related to each other. What is important is to acquire better knowledge on the "why" and "how" of these relationships. Central to this problem of interaction is the nature of the driving force and the resulting perceived environmental system. As we all know, the status of the environment depends upon a complex series of actions and inactions at all levels of government, industry, natural processes, and human behavior, to name but a few. Such actions occur in a highly decentralized fashion. Those of you with responsibility for environmental management know well what your sphere of influence involves -- whether it be geographical, jurisdictional, legislative or economic. Thus, from the perspective of prediction or forecasting, major problems arefaced in terms of measuring both the nature of these decentralized actions and, perhaps more importantly, their interrelationships.

All forecasting starts from the premise that there are certain continuities running through the past and present into the future, and that the reactive or response type of decisions can be assumed to have relative relationships. In predicting environmental consequences of policy choices, the assumption that a first order forecast is a simple extrapolation may be inadequate, because the complexities and subtleties of the interactions are simply not well understood, and the multitude of unforeseen branchpoints downstream preclude this type of approach.

Another difficulty in forecasting involves the risk of deceptiveness of short-term considerations. On the one hand, such a risk justifies the need for long-range forecasting, since assumptions made about the near-term future are often spurious with respect to the longer-run ramifications, which may be irrevocable. In practice, however, the complexities to be dealt with in forecasting are normally assumed to be of one form or another based upon our best estimates of the future, which usually amount to short-term considerations. Thus we have a double-edged sword -- we are continally faced with the need for long-term forecasting but constrained by near-term comprehension and understanding, coupled with the demand for near-term decisions.

Furthermore, we must consider the issue of validation. Assessment of the implications of policy choices is critical to effectiveness, and the quality of our techniques for conducting such assessments is fundamental to the process. There is much information in the literature describing the problems and needs of validation, but the state-of-the-art is imperfect. Essentially, one must be continuously conscious of the issue and strive to improve the methodology as experience is gained. Effective forecasting of the past to the present is a minimum test of validation, but by no means sufficient, primarily because our models, drawing from past experience, are expected to optimize such forecasts.

In summary, there are difficult and complicated problems involved in forecasting. These must all be taken into account and internalized as one attempts to develop a capability for strategic assessment.

On the positive side, however, there are numerous significant benefits to be gained from attempting to forecast future problems. From a policy-making point of view, the ability to consider the likely long-range and comprehensive implications of policy choices can contribute substantially to policy effectiveness.

First, one can have the benefit of organization of thought. Strategic assessment requires structuring choices, considering ramifications and attempts at predicting impacts, all of which demands some set of rational criteria by which policy choices can be evaluated. The concept of

"alternative futures", or the consideration and evaluation of alternative states of the environment, is one such example. With an effective forecasting capability, one can develop certain scenarios within the general limits of expected growth trends or patterns and evaluate the likely outcomes or impacts upon environmental quality. Only by organizing and bounding the possible futures can one rationally consider alternatives for growth policies.

Another benefit is the ability to help move environmental policies in the direction of protection. With an ability to foresee long-range pollution problems, in an "early-warning" sense, one can consider corrective actions in the interim to protect rather than only to regulate or penalize. Thus new policy options are surfaced which may have been overlooked. Policies in the areas of incentives, land use planning, risk avoidance, and conservation, for example, may be shown to be of greater long-range value or, alternatively, shown to be of little overall consequence, if not counter-productive in certain respects.

Effective strategic assessment can also assist environmental managers in decision making. As some of the speakers at this conference are pointing out, we can no longer assume that the natural abilities of the market place and our behavioral patterns will self-correct or, in other words, automatically turn the environment around toward quality. Rational consideration of various management strategies and actions is necessary before problems result from poor or nonexistent planning. In particular, our technological and institutional solutions need to be broadened to include the long-range effects of our actions or inactions. In this context, forecasting within a comprehensive framework can assist the management of policy making.

One example of this concept is the ability to use forecasting as a means to track progress in reaching goals. For instance, a growth policy may be established which is designed to reach a long-range goal of a specified quality of life. Forecasting techniques can then be applied periodically to assess the actual progress being made over time toward achievement of the goal. In this way, mid-course corrections can be made in the policy or, if necessary, in the goal statement.

In a similar fashion, one can measure the impact of alternative policies. For instance, if a mid-course correction were implied, a set of alternative growth policies could be tested at that point in time and evaluated according to their relative impacts upon the environment and thus their projected progress toward reaching the stated goal. In this way, the forecasting system would be sensitive to perturbations in that progress, for example, unforeseen value changes, and would highlight those areas in need of modification.

It is clear that one does not have to produce a perfect forecast system in order to obtain many of the above benefits. Let me now highlight a few of the characteristics of SEAS which is being designed in general to acquire the previously mentioned benefits:

First and foremost, SEAS is a research project. As such, it is time-phased in its development cycle. The research plan revolves around our ability to synthesize the available state of the art in techniques and methods for assessing long-range comprehensive pollution problems.

SEAS has a number of attributes, the collection of which differentiate it from other models and systems which have been attempted in the past. Some of these are as follows:

1) SEAS will deal explicitly with pollution generators and possible controls and known effects of residuals;

2) It is to be a national-level model system for use by EPA Headquarters and Regional policy makers;

3) It is to have a 10 to 20 year time horizon;

4) It will make use of "official" environmental, economic and demographic data;

5) It is to be used together with expert opinion to maximize the combined man-machine capabilities; and

6) SEAS will project the state of the environment and socio-economic systems in the 10 to 20 year planning period that would likely result from alternate projects of population growth, technological change and economic activity levels, and the effects of environmental policies in a comprehensive context.

Thus SEAS is to be a complex model system, attempting to tie together in a comprehensive sense the interrelated areas of environmental and socio-economic factors. For those of you interested in the details of SEAS and the design process, I refer you to the Technical Workshop later this morning hosted by our Environmental Studies Division and the SEAS contractors.

At this workshop, you will be able to learn about the progress made over the past six months on the SEAS Test Model. This test model is being done as a research tool for the development of the SEAS Prototype Model that will be completed by December and used to prepare a "1980 State of the Environment" projection. The prototype will be a state-of-the-art system insofar as it will incorporate the best available submodels into the

comprehensive SEAS context. We are now in the process of surveying various federal and state/local agencies, research institutes, universities, and private firms for the most appropriate set of techniques and data bases for the SEAS Prototype. One of the final products of the SEAS prototype effort will be complete documentation of the effort and an estimate of what benefits and costs would be incurred from proceeding further toward the full SEAS system.

Let me now mention briefly some ideas we have for the applications of SEAS when it is developed.

Initially we envision SEAS aiding in the assessment of alternative policies in terms of their long-range impact on the environment. This use we view as a "process", whereby SEAS, as a computer-based system of models, will be augmented by human expert opinion in an integrated analytical fashion. State of the Environment Reports can be produced, which result from man-machine analysis of the long-range ramifications of current and contemplated environmental policies upon the Nation and Federal Standard Regions.

This initial use could also involve assisting us in the illumination of possible research goals and needs. If it is possible to describe the environmental system, it may then follow that sensitivity tests may help in identifying potential gaps in the sense that our information in certain areas may be lacking and the particular gap may be more important than we thought. Our goal of a better understanding of the way the total environment interacts with itself, with man, and with all the elements that go to make it up, may be broken down, with the help of SEAS, into relative critical components with varying research needs.

Ultimately SEAS could be helpful in formulating policy choices and in monitoring the overall progress of the Nation or region in reaching policy goals. Obviously this will require effective solutions to the forecasting issues I mentioned earlier. But we are hopeful that development of the Prototype will indicate that it can be done, because this is the most effective way we can hope to anticipate long-range problems and to take proper actions to prevent them from occurring. For instance, we know from experience that the problems we face today are not necessarily those we will fact at some time in the future. This is the principal reason that technology alone rarely solves problems. Institutional and societal factors and values really determine the success of proposed solutions. With an effective forecasting system such as SEAS we may have the capability to consider new policy options and assess their ramifications upon the total environment.

Finally, I want to suggest to you that the concept and process underlying SEAS is directly applicable to your organizations and objectives. As

you move toward a more comprehensive and integrated view of managing the environment, the process of organizing and synthesizing the best available information to consider alternative policies can be extremely beneficial as a management tool.

We believe SEAS is a very worthwhile research project. It is being developed carefully and documented completely and I encourage you to follow its progress and take advantage of our experiences. Since we have the same environmental management goals, our techniques and methodologies should be shared.

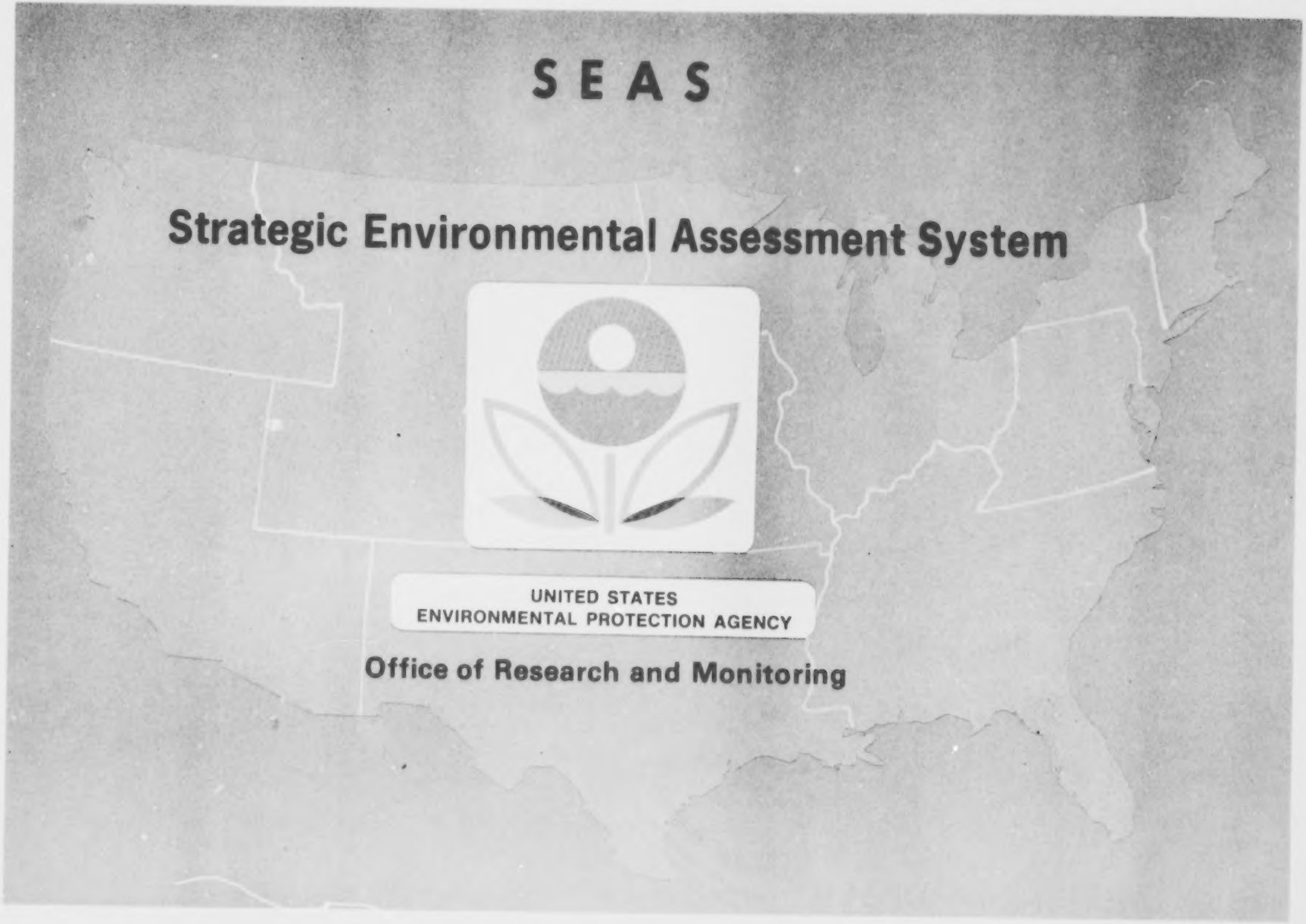
Thank you.

BRIEFING CHARTS ON SEAS

Presented By
The Environmental Studies Division, EPA
and SEAS Contractors for the SEAS
Technical Workshop

at the
National Conference on Managing
the Environment

Washington, D.C.
May 14-15, 1973


SEAS
Strategic Environmental Assessment System
UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY
Office of Research and Monitoring

TOPICS

1. Need for Strategic Assessment
2. Project Goals & Objectives
3. SEAS Development Program
4. System Components
5. Policy Making Applications
6. Summary

TOPICS

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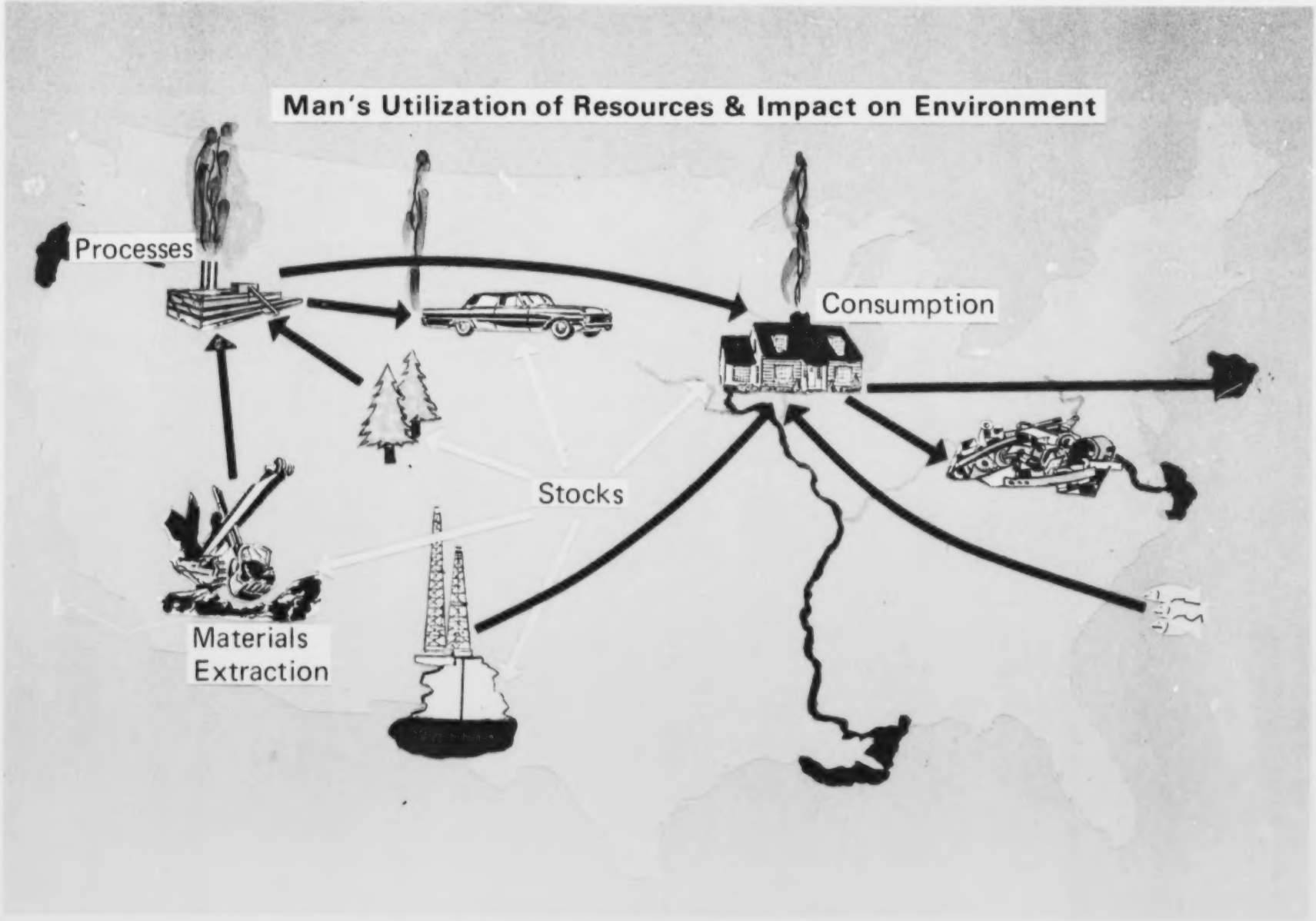
Man's Utilization of Resources & Impact on Environment
Processes
Consumption
Stocks
Materials
Extraction

STRATEGIC ASSESSMENT

". . . Effective Strategy for national environmental quality requires a foundation of information on the current status of the environment, on changes and trends in its condition, and on what these changes mean. . . ."

(CEQ, 1970)

Concept of Long-Range, Comprehensive Environmental Planning

- Legislative Basis
  - National Environmental Policy Act of 1969
  - Federal Reorganization Plan of 1970 – EPA
  - Clean Air Act of 1970 (As Amended)
  - Water Quality Improvement Act of 1970 (As Amended)
  - Resource Recovery Act of 1970

Concept of Long-Range, Comprehensive Environmental Planning

- Policy Basis
  - President's Messages to Congress on Environmental Protection
  - CEQ Annual Reports on Environmental Quality
  - U.N. Conference on the Human Environment
  - Administrator of EPA Policy Speeches and Remarks

Overall EPA Policy Making Activities

- Standards-Setting and Enforcement
  - Determination of Kinds of Levels of Pollutants
- Research and Development
  - Provide Scientific Base for Environmental Action
- Technical and Financial Assistance
  - Regional Program Delivery Systems
- Manpower Development and Public Information
  - Education and the Environmental Ethic

Goal: Pervasive and Continuing Environmental Quality

TOPICS

1. Need for Strategic Assessment
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ORM Research
U.S. Environmental Protection Agency

Objectives

- Provide a sound scientific basis for the Agency's program of operations
- Formulate and execute a comprehensive research program adequate for the current and expected future informational needs of EPA
- Facilitate the interchange of information between analytic research and operational field solutions to environmental problems

SEAS Objective

Provide a comprehensive means for evaluating the long range impact of trends, processes, activities and policies on the environment.

- National/Regional Level
- Multi-media Pollution Generators and Effects
- 10-20 Year Time Horizon
- Combined Man/Machine Capability
- Alternative Scenarios

SEAS Phases

Phase I (Sept. '72 – June '73)
- Concept Formulation
- Test Model Development & Operation
- Prototype Definition
- Prototype Development Plan

Phase II (June '73 – Dec. '73)
- Prototype Development
- Assessment of State-of-Art
- Comprehensive System Requirements
- Comprehensive System Development Plan

Phase III (Dec. '73 –)
- Comprehensive System Development
- Policy Applications

TOPICS

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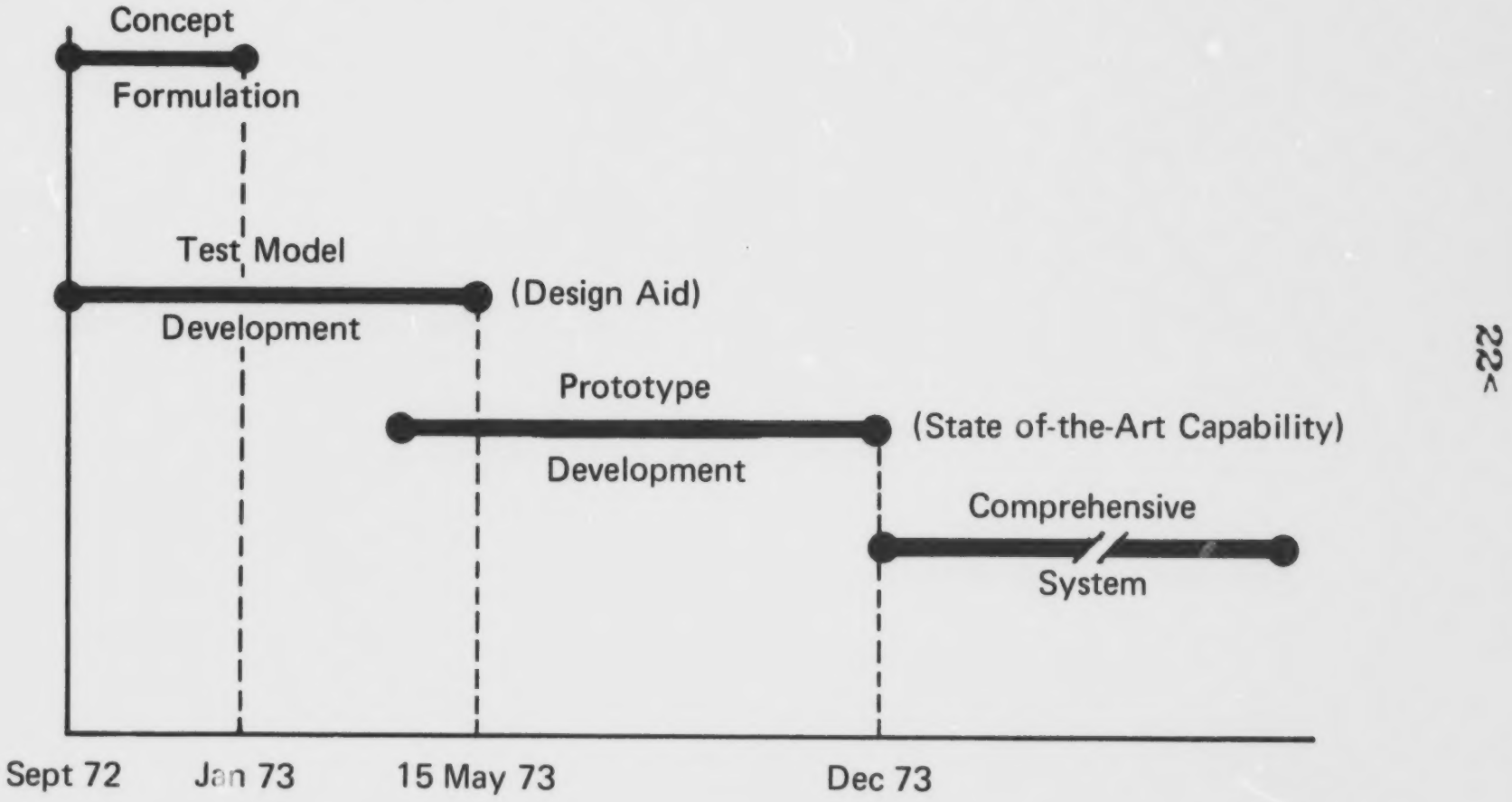
SEAS Schedule



Typical Model Development Problems

- Data Limitations
- Limited Flexibility
- Lack of Early User Inputs
  (Model Design Independent of User Needs)
- Quantitative/Qualitative Requirements
  (Social, Economic, Environmental)
- Validation
- Tradeoff Criteria

SEAS Development Process

- In-House/Contractor Effort
- Utilize Interdisciplinary Experts
- Coordinate with Other EPA Offices/Regions
- Open Design
- Address Policy Maker Needs
- Expert Opinion

TOPICS

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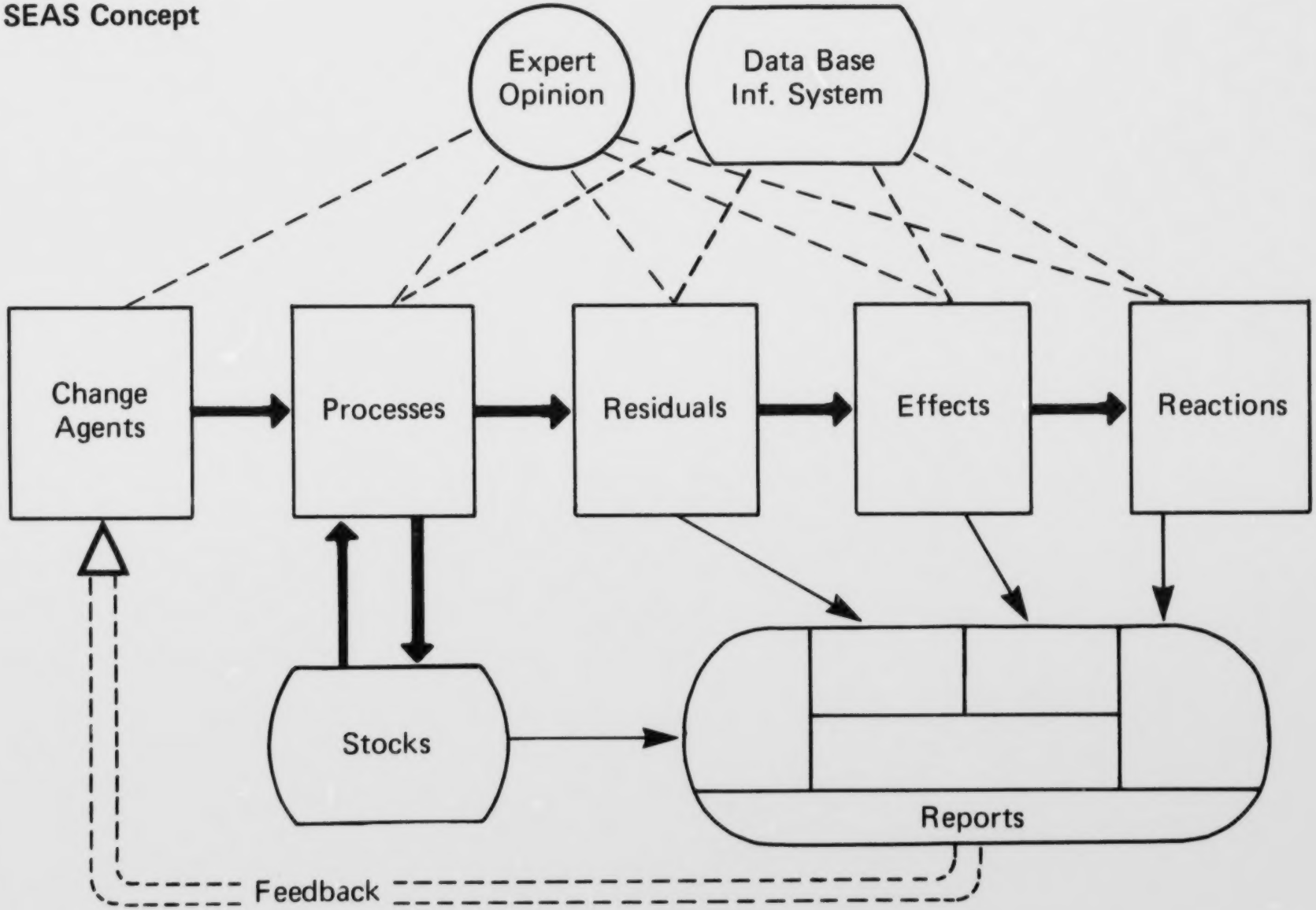
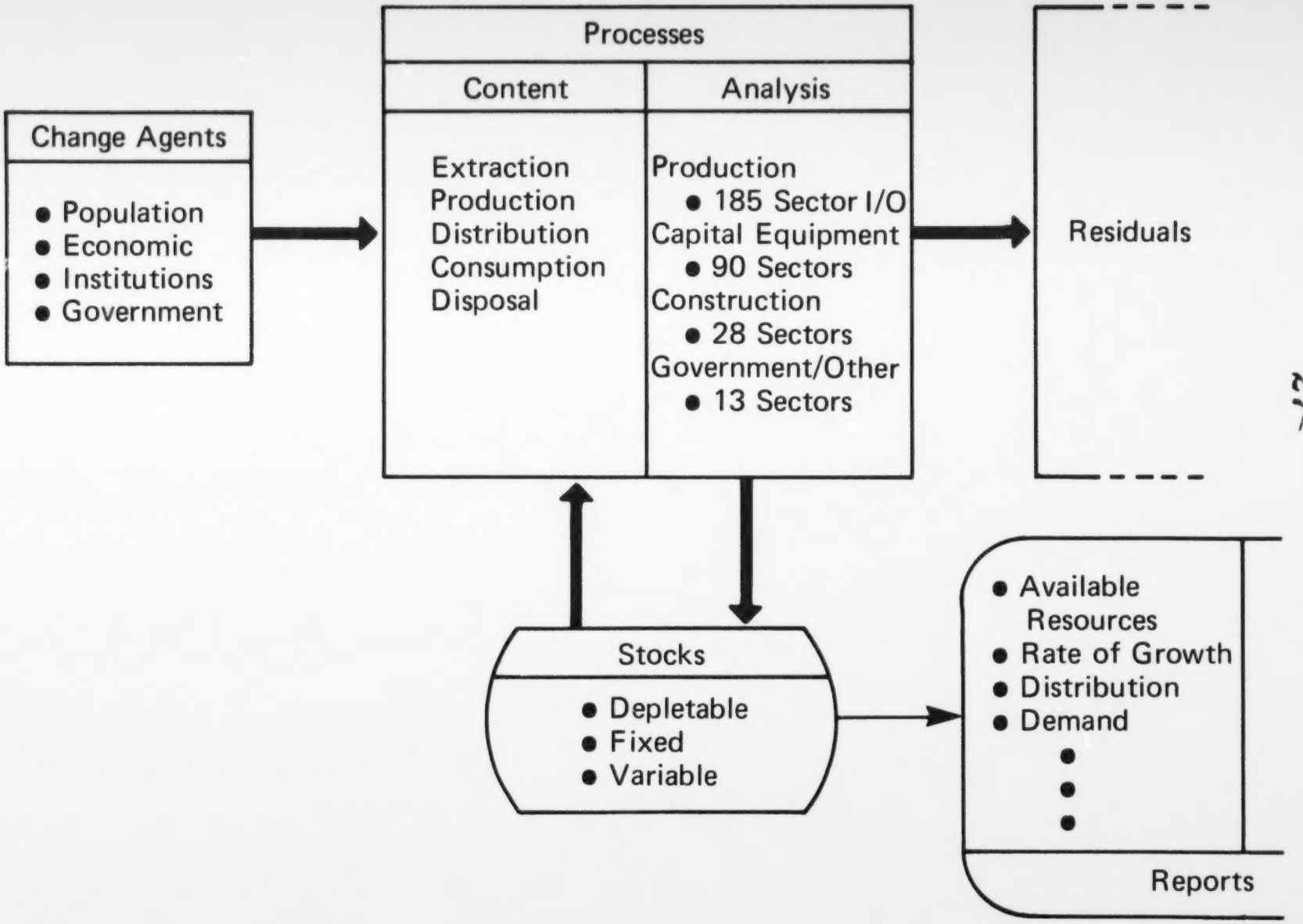
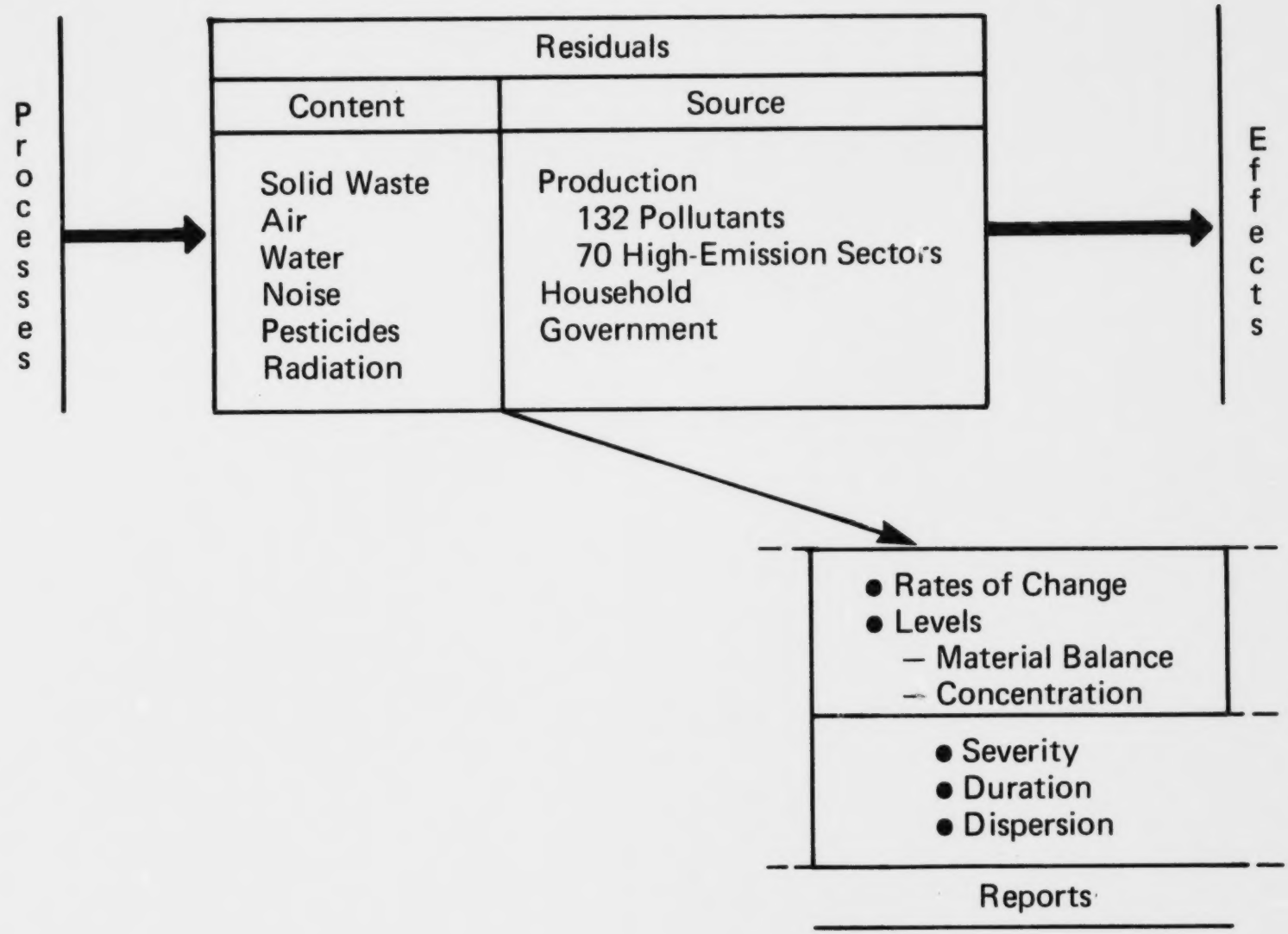
SEAS Concept



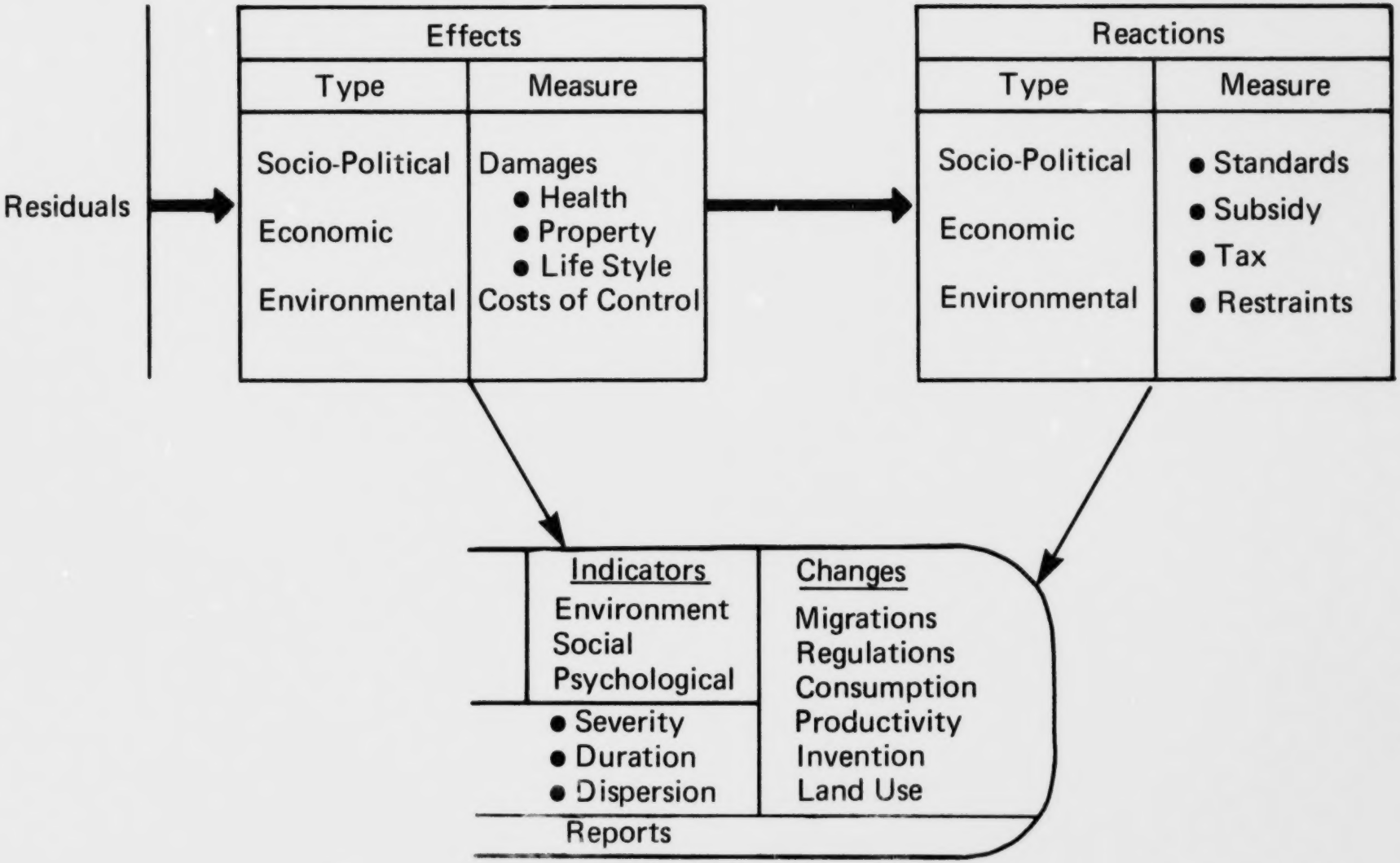
Processes/Stocks



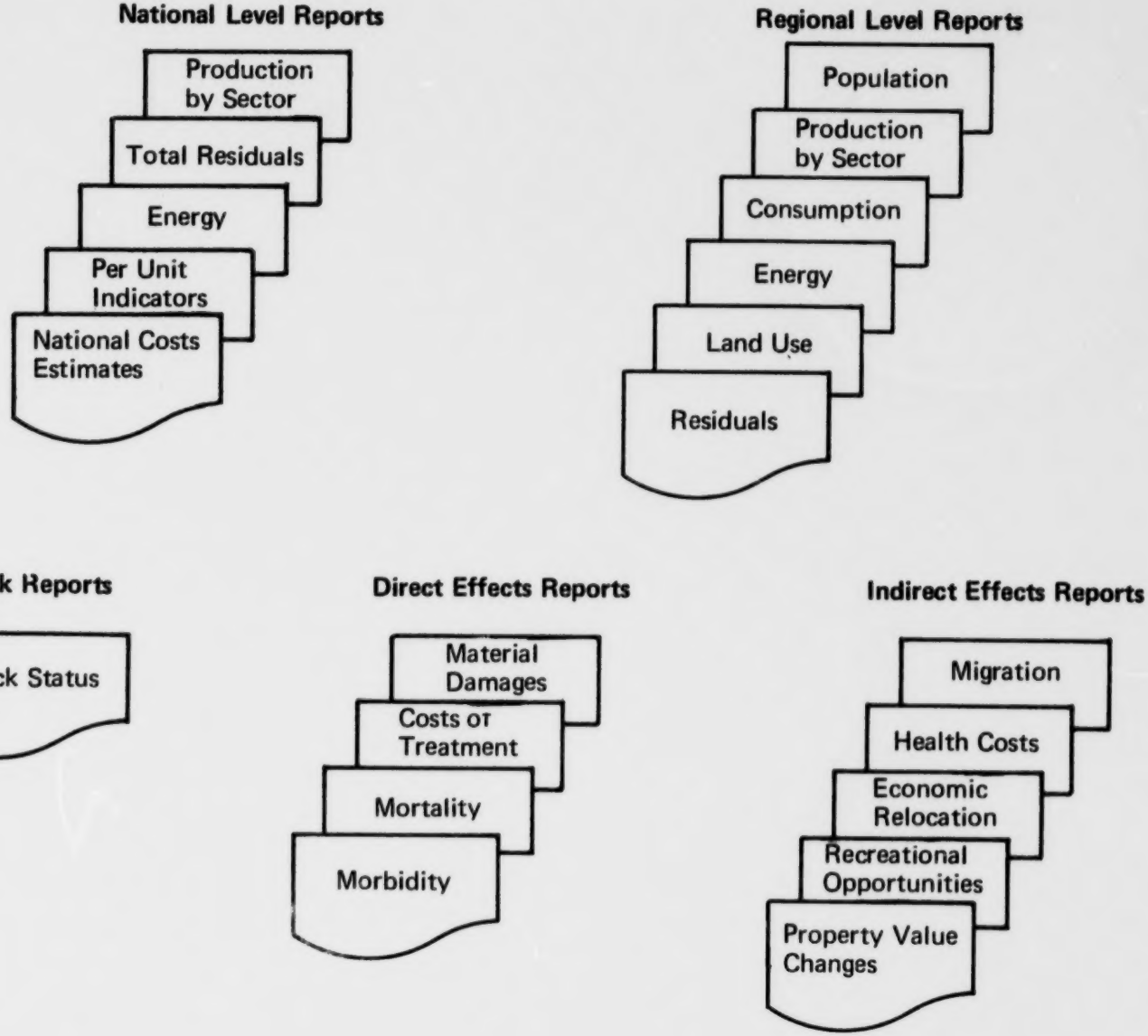
Residuals


Processes
Residuals
Content
Source
Solid Waste
Air
Water
Noise
Pesticides
Radiation
Production
132 Pollutants
70 High-Emission Sectors
Household
Government
Effects
• Rates of Change
• Levels
– Material Balance
– Concentration
• Severity
• Duration
• Dispersion
Reports

Effects/Reactions



SEAS Outputs



SEAS Information System

Contains Demographic, Economic & Industrial Data by Geographic Area:

- National
- Regional
- State
- SMSA
- County

Based on Demographic Assumptions:

- Population Growth
- GNP Growth
- Employment Rates

TOPICS

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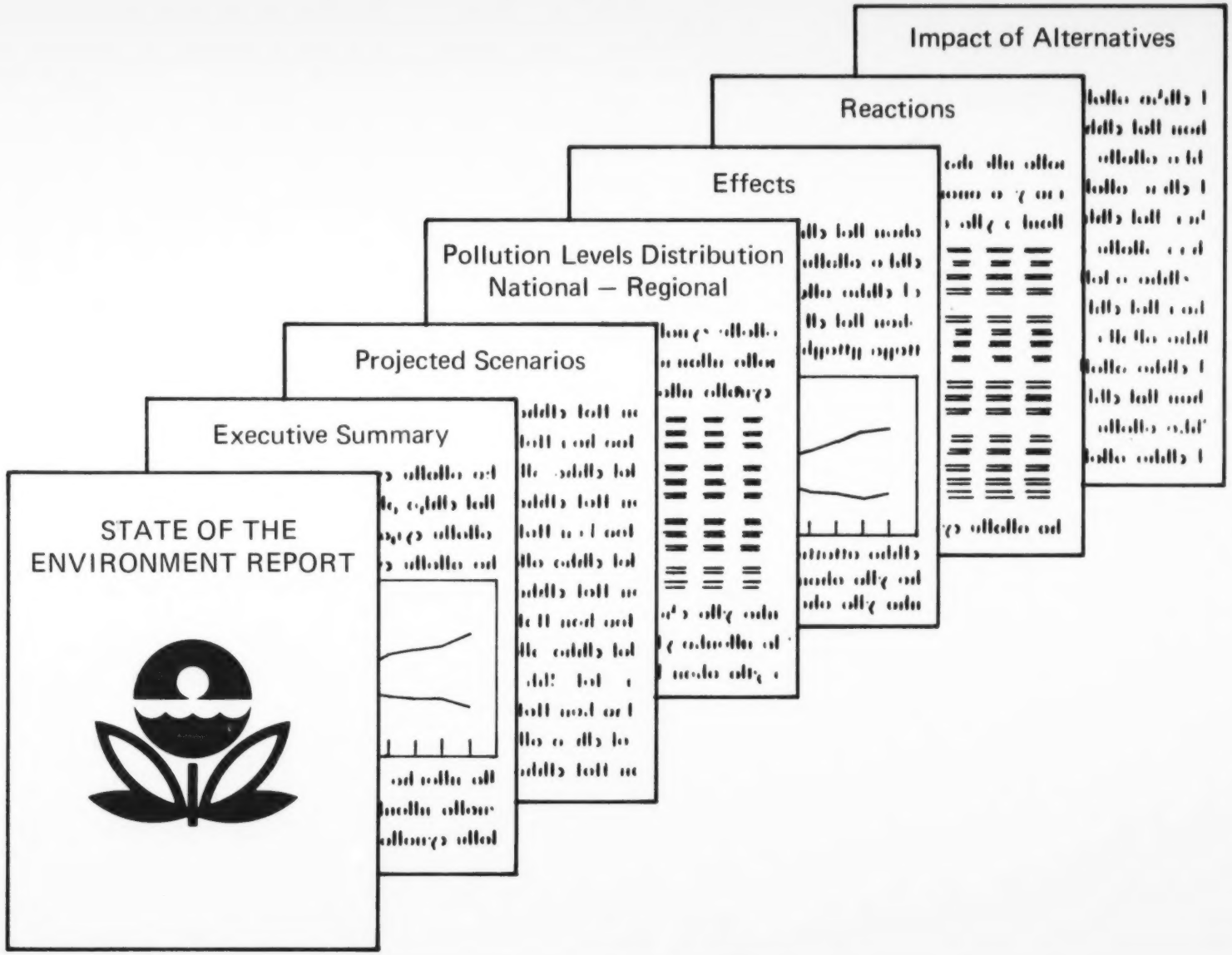
Policy Making Applications

- Policy Level Issues
  - Consider Alternate Futures
  - Long Range Comprehensive Planning
  - Anticipate Problems
  - Illuminate Research Needs

State of Environment Report



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SUMMARY

- Responds to Key NEPA Mandates
- Extends Capability of EPA
- Ambitious but Necessary for Policy Making
- Development Program Alleviates Critical Problems
- A Research & Development Project
- Effective Man/Machine Capability

SEAS

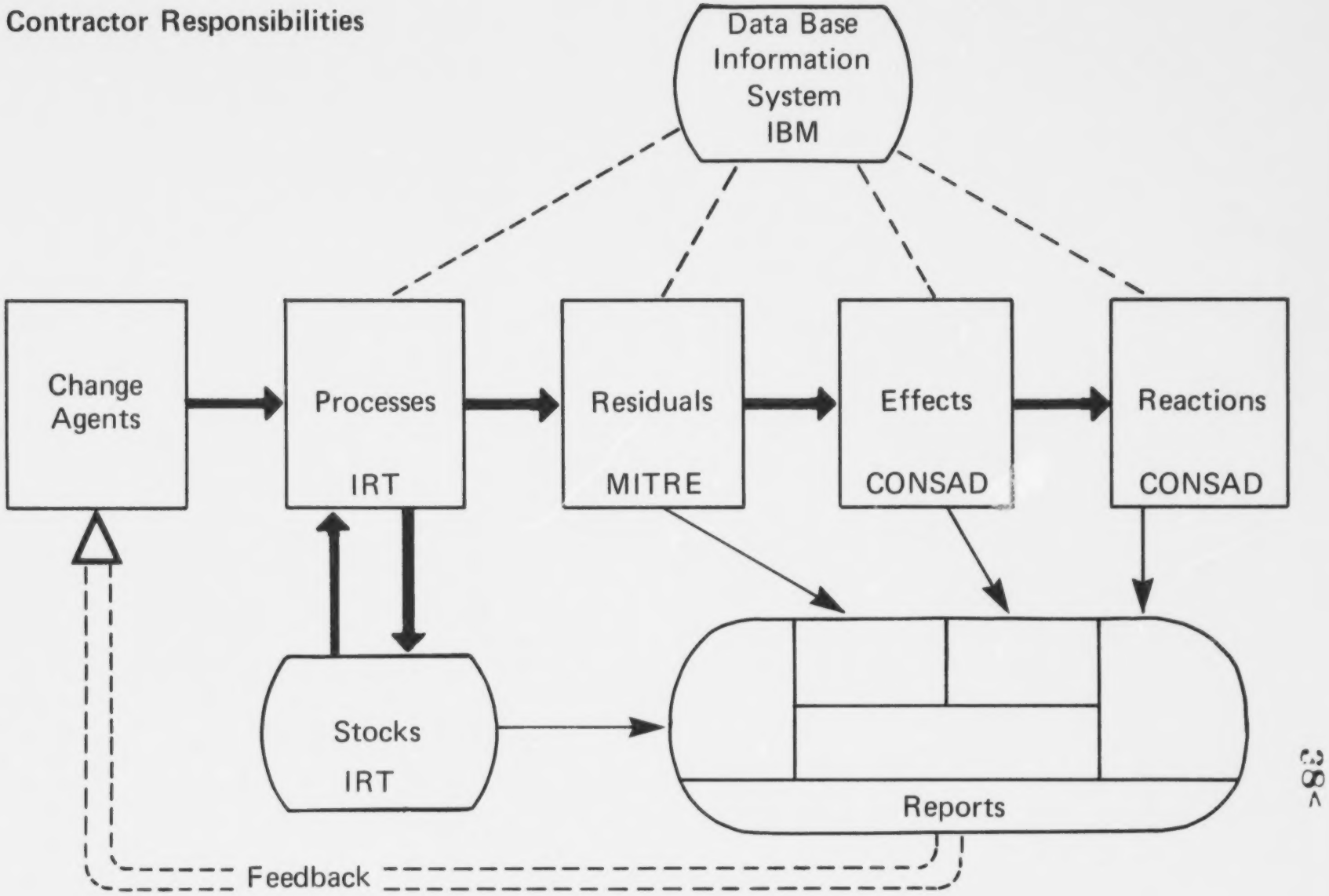
Strategic Environmental Assessment System

UNITED STATES
ENVIRONMENTAL PROTECTION AGENCY

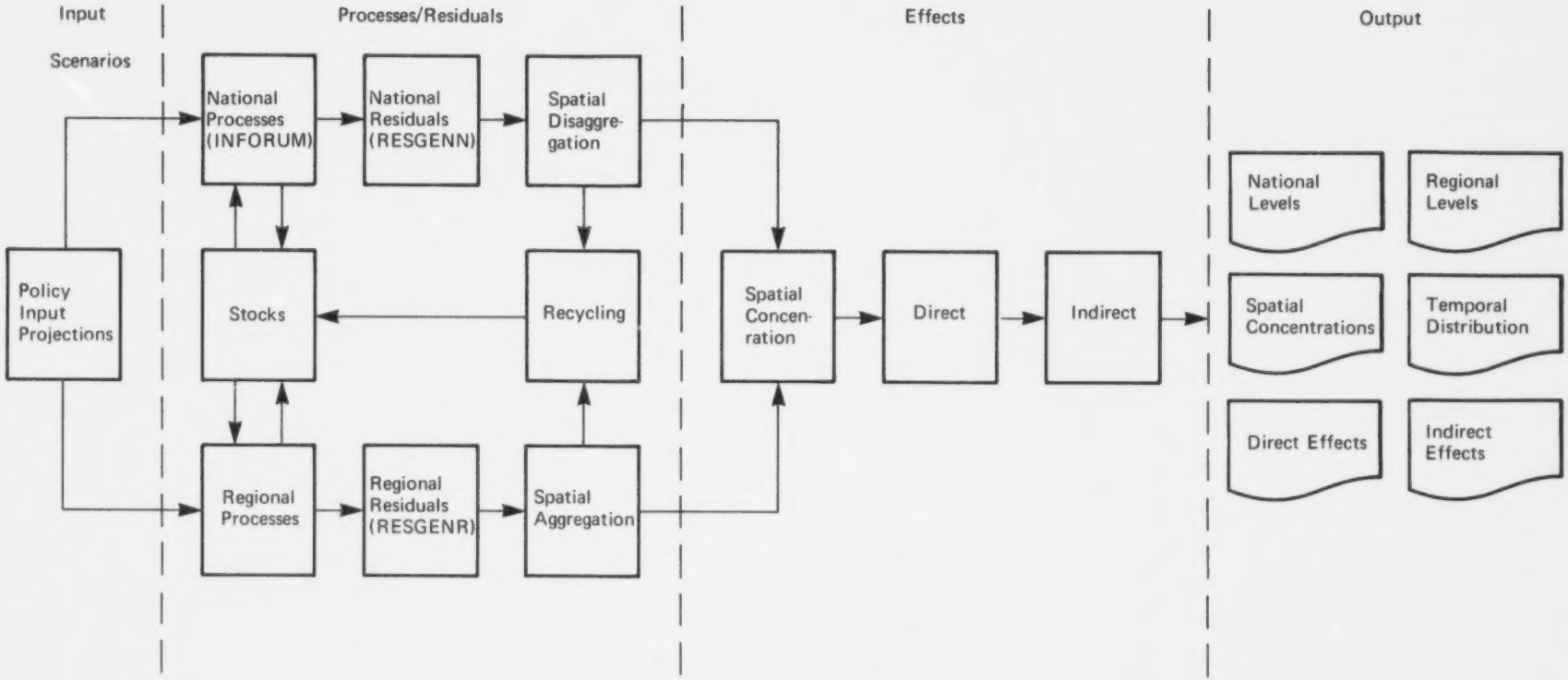
Office of Research and Monitoring

S.S.A.

Contractor Responsibilities



SEAS Test Model Flow



Input Scenarios

Number	Description
1	1970 Base Year State
2	Pop. Series 'E', Med. Econ. Growth
5	Pop. Series 'E', Med. Econ. Growth, 1970 Control Technology
6	Pop. Series 'E', Med. Econ. Growth, Private Affluence
7	Pop. Series 'E', Med. Econ. Growth, Revenue Sharing
9	Pop. Series 'E', Med. Econ. Growth, Recycling
3	Pop. Series 'E', Low Econ. Growth
4	Pop. Series 'E', High Econ. Growth
8	Pop. Series 'D', Medium Econ. Growth
10	Pop Series 'F', Medium Econ. Growth

Processes/Residuals

National

INFORUM

- Embraces the Entire Economy
- Sectoral Detail
- Maintained Forecasting System

RESGEN

- 70 Sectors and 132 Pollutants, all Media
- Emission/$ Output

Regional

- Automobiles
- Space Heating
- Agriculture and Animal Husbandry
- Emission Factors

Stocks

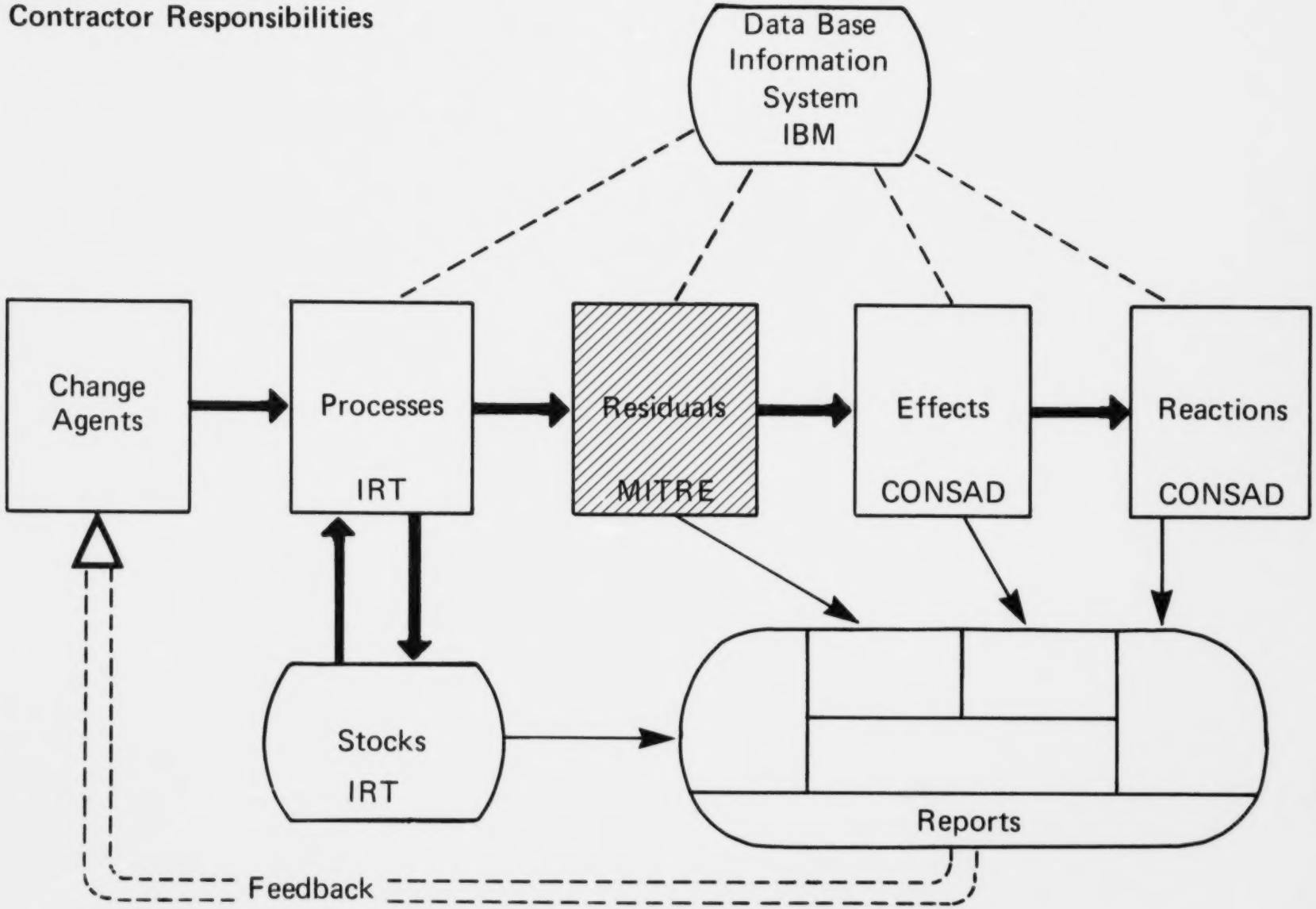
- Fuel use
- Mineral use
- Scarcity Index

Effects/Reactions

Air – SMSA Level

- Health
  - Mortality Rates
    - Total
    - Infant
  - Morbidity Rates
    - Respiratory System Cancer
- Property Damages
- Temporal Distribution of Concentrations and Related Effects

Contractor Responsibilities



SEAS:

Initial Analysis
of
Environmental Residuals

Initial Number of Residuals

Air	54
Water	76
Solid Waste	17
Pesticides	215
Radionuclides	78
Noise	118
	558

Important Air Residuals

- Particulates
  - Arsenic
  - Asbestos
  - Beryllium
  - Cadmium
  - Fluorides
  - Lead
  - Mercury
- Gaseous
  - Carbon Monoxide
  - Nitrogen Oxides
  - Sulfur Oxides

} Adverse Health Effects
Wide-Spread Use
Produced in Large Quantities
Highly Toxic
Ambient Standards

Important Water Residuals

Arsenic
Boron
BOD
Cadmium
Chromium
Cyanide
Lead
Mercury
Nitrates

Highly Toxic
Adverse Health Effects
  Human
  Other Biota
Wide-Spread Use
Water Quality Standards

Important Solid Waste Residuals

Industrial Sludge	Produced in Large Quantities
Inorganic Chemicals	Chemically Complex
Mine Tailings	Toxic
Municipal Sludge	Difficult to Dispose of
Organic Chemicals	
Slag and Ash	

Important Pesticide Residuals

Organochlorines
- DDT
- Dieldrin
- Heptachlor
- Heptachlor Epoxide
- Toxaphene

Organo Phosphorus
- Parathion/Paroxon

Herbicides
- Dioxin (An Impurity)
- Picloram

} Long Persistence
High Toxicity
Wide-Spread Use
Bioaccumulation
Species Specificity

Important Radionuclide Residuals

Cobalt – 60	High Fission Yield
Krypton – 85	Critical Pathway
Strontium – 90	Long Half Life
Iodine – 129	Biological Affinity
Iodine – 131	Radiation Emitted
Cesium – 137	

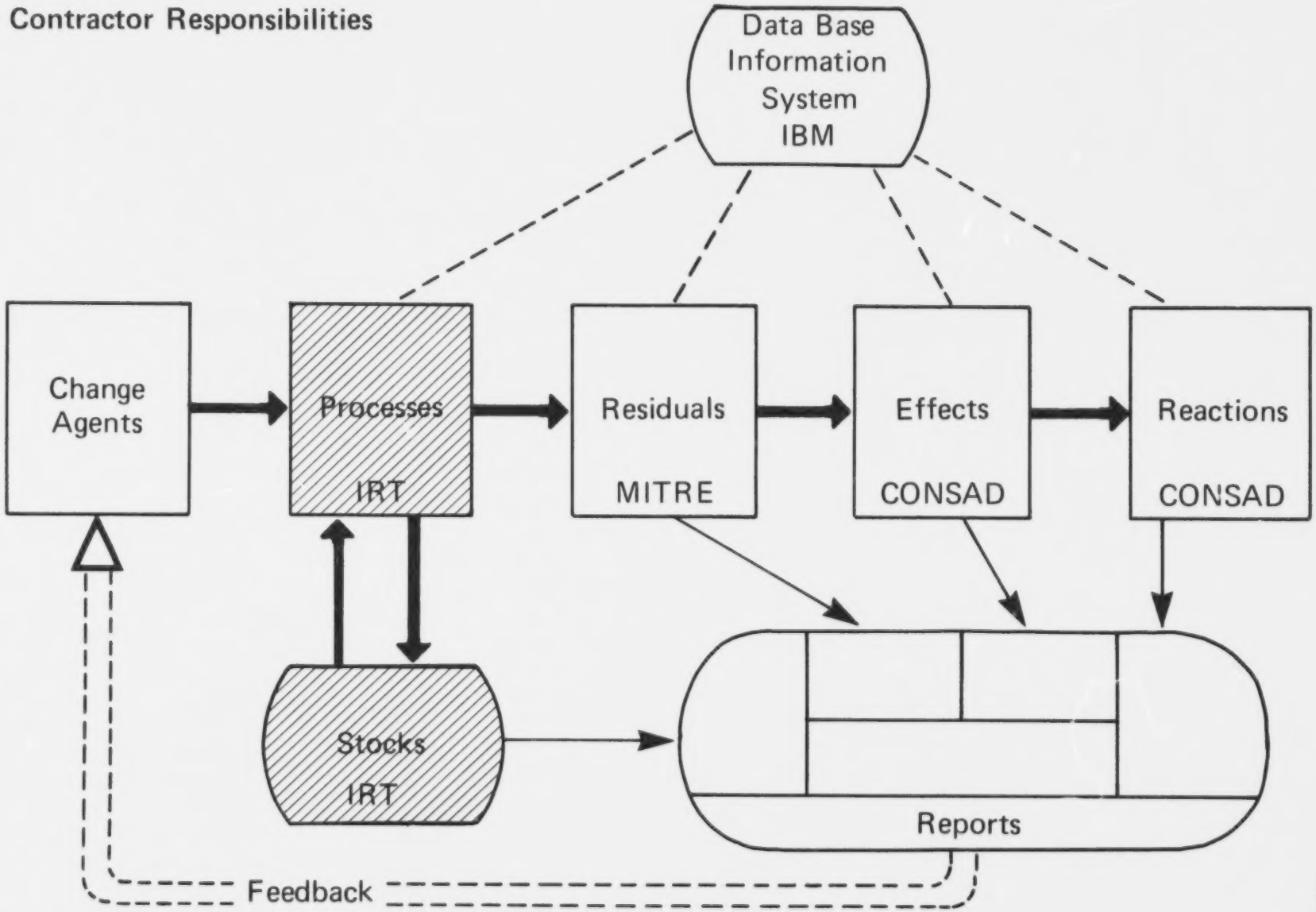
Important Noise Residuals

Airports	Intensity
Amplified Entertainment	Number of People Exposed
Construction Equipment	Damage Potential
Industrial Noise	Avoidability

Initial Number vs. Important Residuals

	Initial	Important
Air	54	10
Water	76	9
Solid Waste	17	6
Pesticides	215	8
Radionuclides	78	6
Noise	118	4
	558	43

Contractor Responsibilities



Four Subtasks

1) Describe residuals generation by processes inadequately covered by INFORUM-RESGEN

2) Describe stocks of scarce resources

3) Regionalize 1) and 2)

4) Forecast 1) and 2)

Subtask 1): Residuals generation by processes inadequately covered by INFORUM-RESGEN

1.1. Residuals generation by final demand "sector", e.g.:

Home heating
Automobile Emissions

1.2. Residuals generation not sufficiently disaggregated in the I-O sector industrial matrix; e.g., Cd, Hg.

1.3. Residuals generation by land use; e.g.,

Urban and rural runoff
Animal wastes
Insecticides and fertilizers
Solid waste and sewage

1.4. Residuals generation affecting or entering natural cycles; e.g.,

NO_x

SO_2

Sr^{90}

Subtask 2): Stocks of Scarce Resources

2.1. Depletable energy resources, e.g.,

Fossil Fuels: coal, gas, oil, etc.

Nuclear Fuels: U^{235}, U^{238}, Th^{232}

Thermonuclear Fuels: d_2, Li

2.2 Rare mineral resources, e.g.,

Hg
Ag
Zn

2.3. Land resources, e.g.,

urban
recreational
agricultural
pasture
forestry

2.4 Renewable natural resources, e.g.,

fresh water
forest
soil

2.5. Capital stock by industrial sector

Subtask 3): Regionalization of residuals-generating activities and stocks

3.1. Regionalization of land-based residuals-generating activities resources, e.g.,

energy resources
mineral resources
land resources
natural resources

3.2. Regionalization of other residuals-generating activities and capital stocks, e.g., on the basis of:

present distribution of plants by region
aggregate distribution by region
population distribution by region
urbanization or other indices, by region

Subtask 4): Forecasting of residuals generation and stocks

4.1. Forecasting of policy variables through "scenarios", e.g., forecasts of:

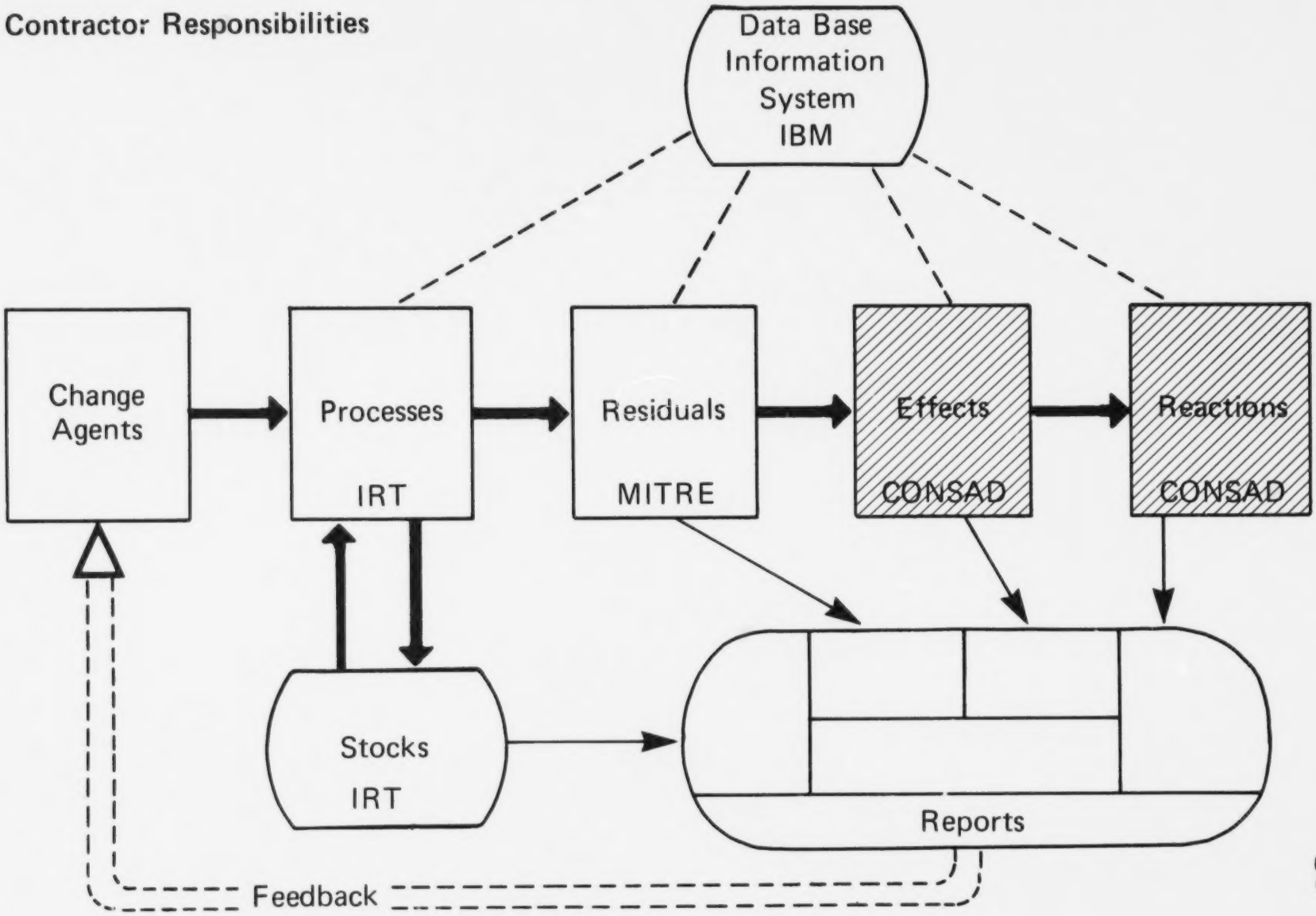
- Population
- Unemployment
- Taxes
- Pollution charges, incentives or standards
- Consumption patterns or life styles

4.2. Forecasting of technological changes, i.e., substitutions of raw materials, intermediate processes or final products as influenced by:

- relative costs
- capital stocks

and other variables. The purpose: to make the I-O coefficients "dynamic"

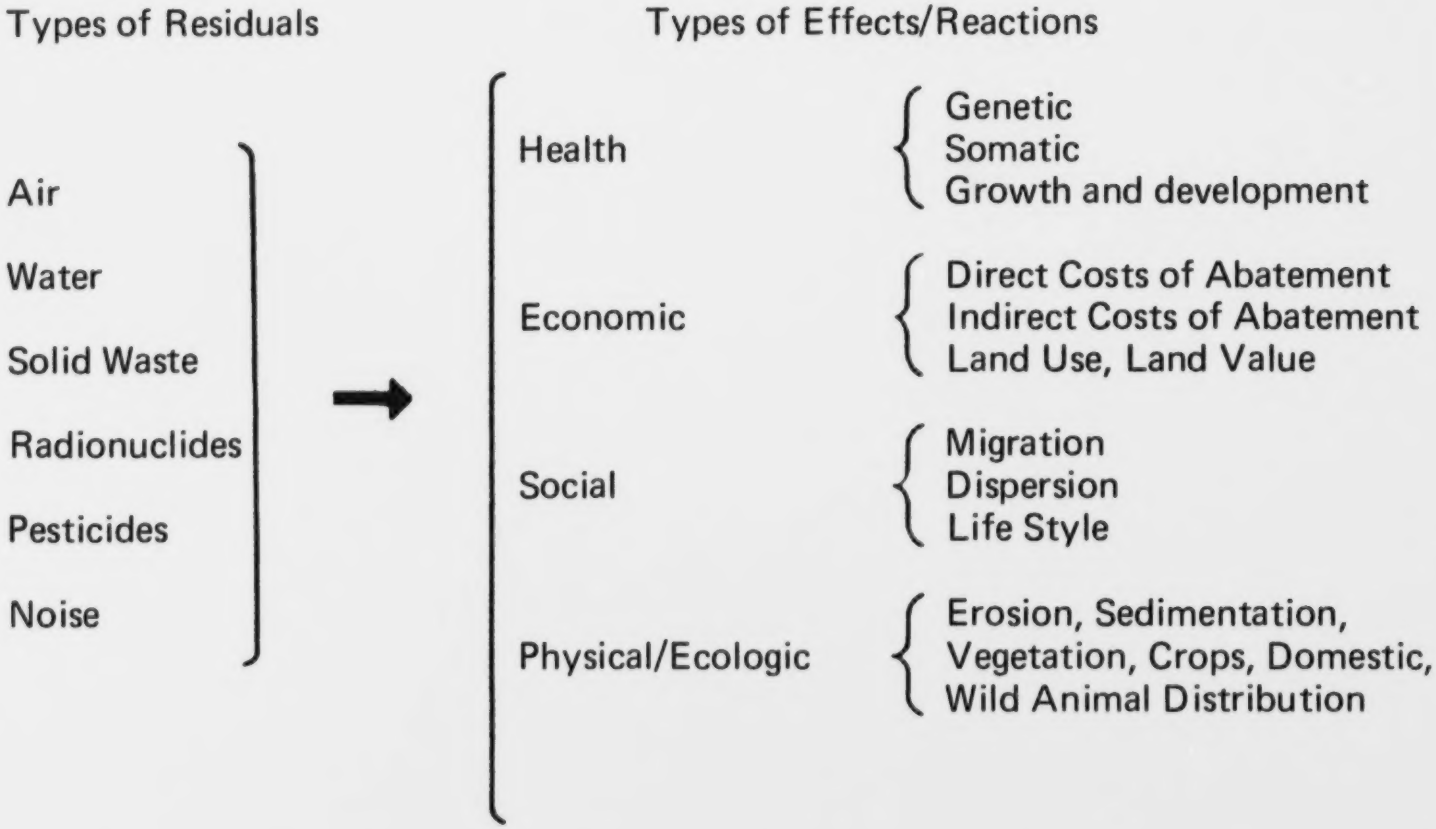
Contractor Responsibilities



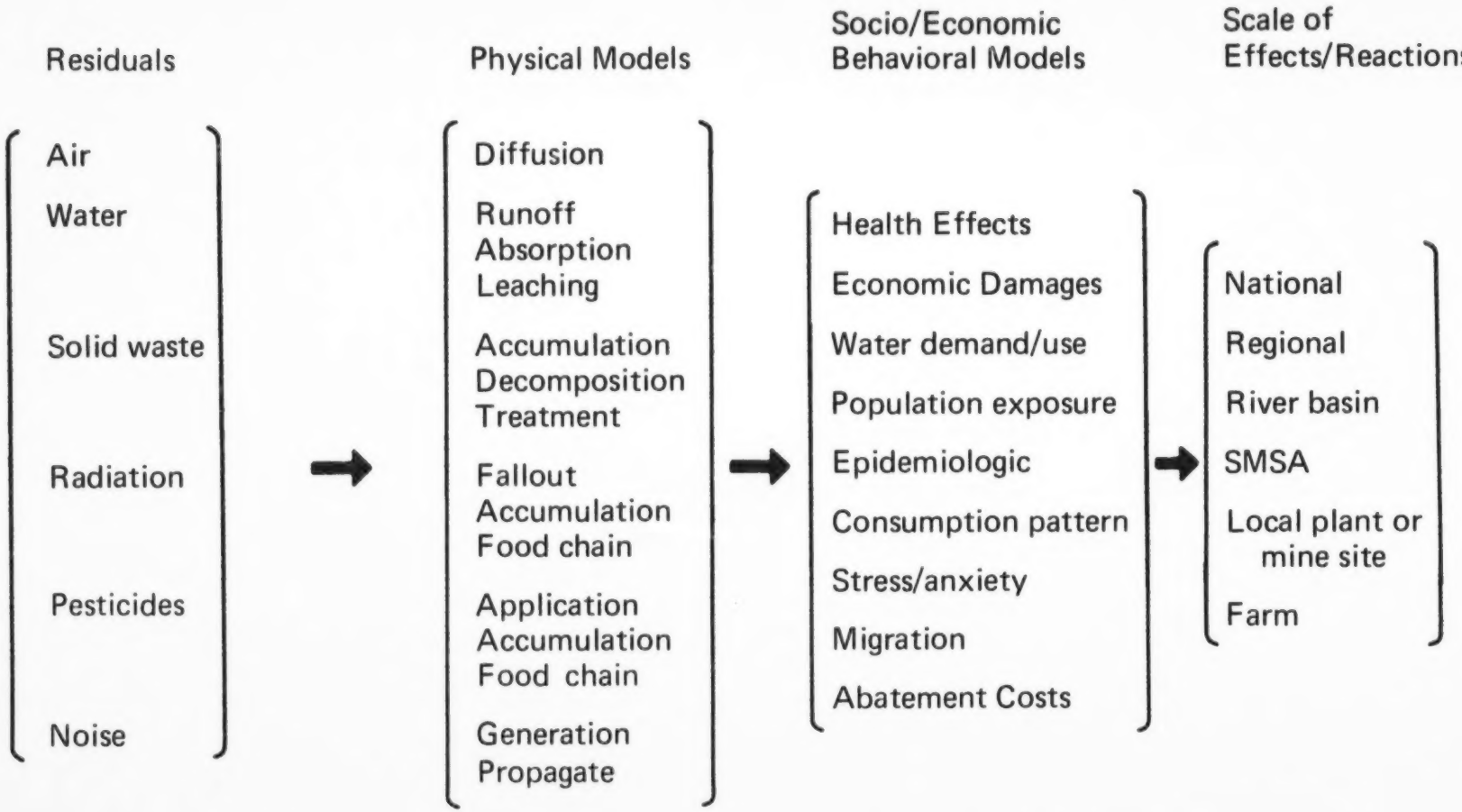
Use of Effects/Reactions Module

- Trace the implications of residuals for people, biota and materials
- Provide opportunity to assess alternate technology/life style scenarios
- Suggest ideas for policy and research

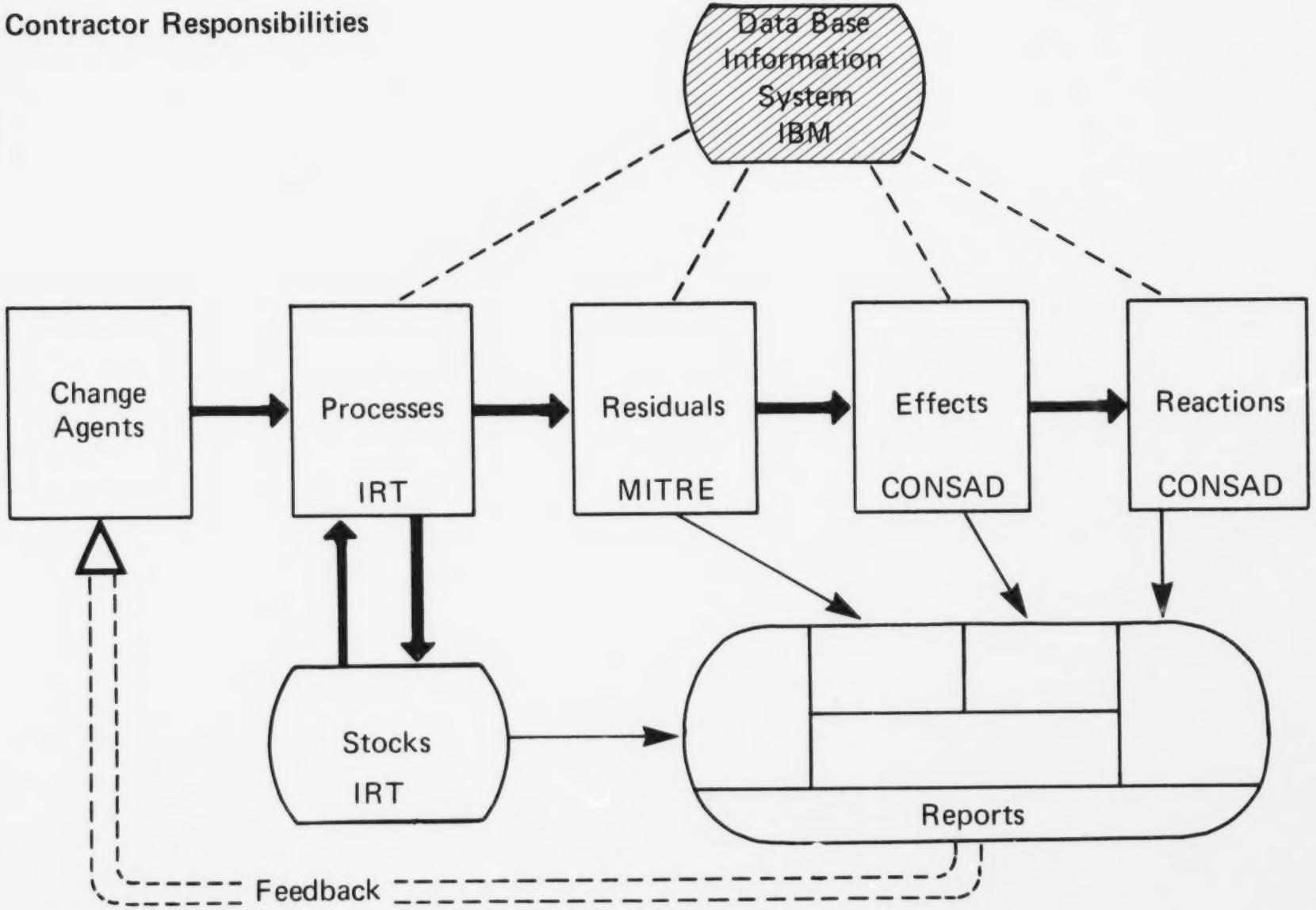
Structure of Effects/Reactions



The Dynamics of Effects/Reactions



Contractor Responsibilities



Summary of Objectives

Right Information

↘

Right People

↘

Right Time

↘

Minimum Costs

SEAS Information System

Input Scenario Data

- Population Growth Rate
- Abatement Alternatives

Profile Data Base

- Demographic Characteristics
- Economic Characteristics

Stock Data Base

- Depletable
  - Reserves
  - Resources
- Renewable
- Fixed
- Man-made

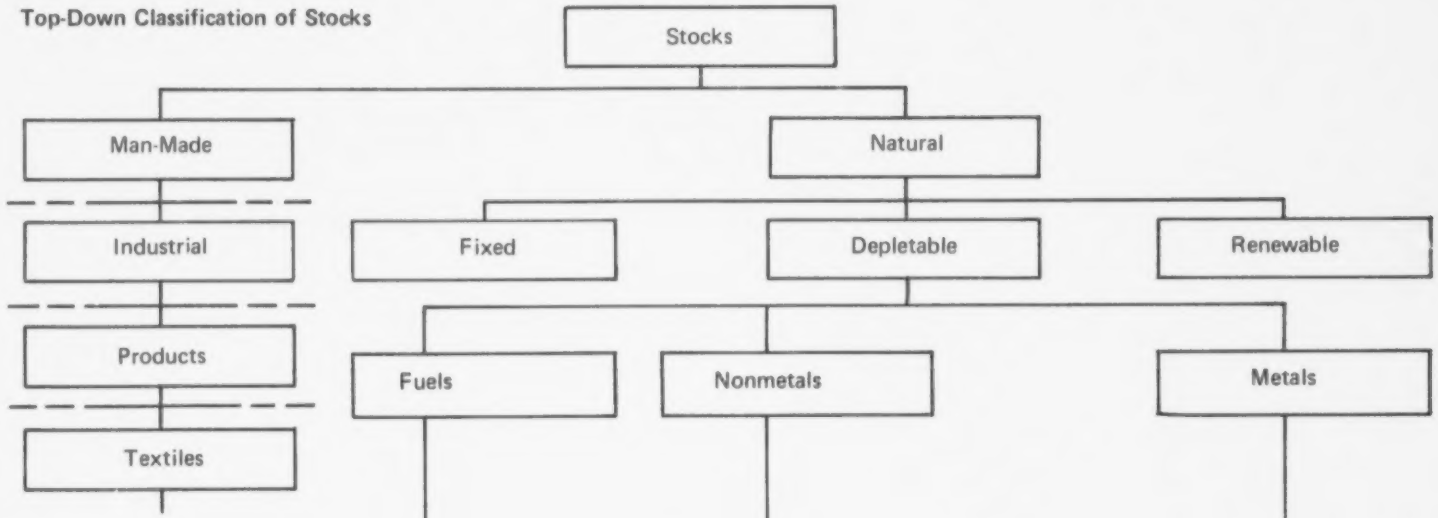
Model Output Data

- Residuals
- Effects
- Reactions

Profile Data Base

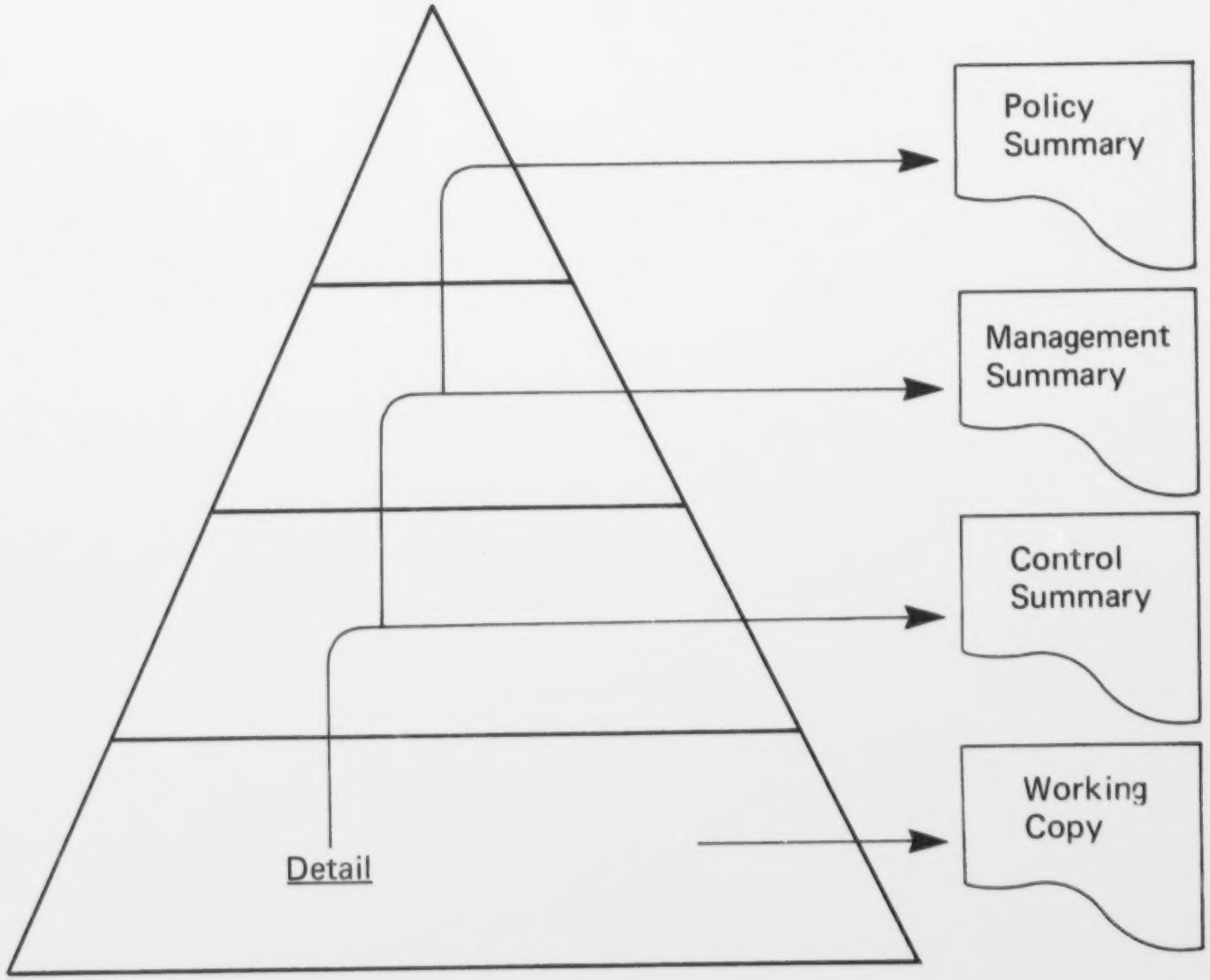
- Preliminary
  - Use in SEAS Test Model
  - Based on County & City Data Book – 1967
    Contains both economic & demographic data
    frequently used

Top-Down Classification of Stocks

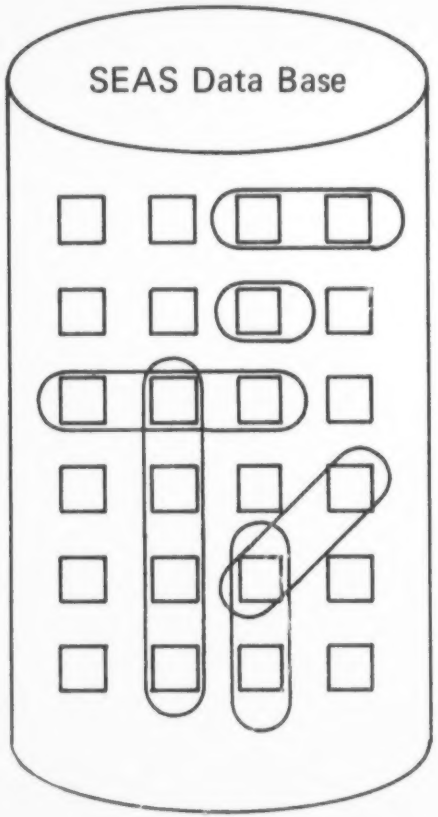


		Oil	Gas	Coal	Asbestos	Cement	Feldspar	Gypsum	Nitrates	Phosphates	Salt	Sulfur	Bauxite	Copper	Iron	Lead	Mercury	Nickel	Silver	Tin	Uranium	Zinc
Location	ID																					
Quantity	Tons																					
Quality	$\frac{\text{Tprod}}{\text{Traw}}$																					
Production Rate	Tons/Yr.																					
Production Cost	$/Ton																					
Market Value	$/Ton																					

Traditional Information Concept



Outputs

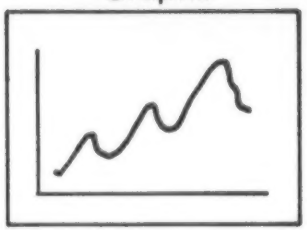


Information Retrieval

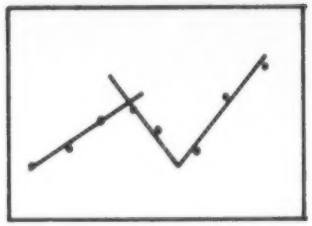
Data Reduction

Data Presentation

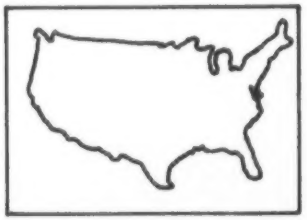
Graphs



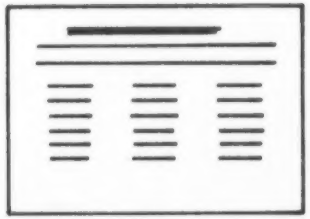
Trend Analysis



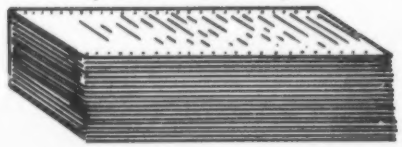
Maps



Statistics



Computer Listings



Information System Functions